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"For 229 years, a strength of the U.S. military has been its ability to adapt and change. As the rate of change of technology continues to accelerate, it will be even more important that the U.S. military keep pace…The greater institutional risk for DoD is over reliance on traditional platforms and delaying the advent of new technologies and systems."

Deputy Defense Secretary-nominee Gordon England, April 2005

US Military Transformation: Decision Rules

The size, and particularly the structure, of the future US military ought to reflect the operational context within which it will operate. Accurately predicting what that operational context will be, however, is very difficult. Taking any prediction as a precise guide for the structure we should build is stupid and dangerous. But some general directions and trends are worth betting on, and one that clearly has merit is a by-product of transitioning to the information age. That is, replacing the goal in military operations to obtain overwhelming physical destruction with the goal of imposing overwhelming complexity on the opponent, a complexity that stems from the US military possessing far more options to use destructive force effectively than any opponent and far more options than an opponent can counter. As a result, the future of the US military belongs to forces that are smaller, faster, more numerous, and networked. It is not smallness, numbers, or speed of the force as discrete elements that have value. It is these characteristics in concert with the high information fraction -- the measure of a system's ability to access and contribute to a higher level of common knowledge – that networking provides.

A Naval Forces Example

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An illustration, of what taking these considerations more aggressively into force structure planning could mean for the US Navy is detailed here. Over the next 15 to 20 years, the Navy plans a fleet modernization process of replacing older ships with newer ones that boosts the size of the fleet from 310 to about 375 ships. In the FY2004 National Defense Authorization Act, Congress mandated two independent studies of naval fleet platform architectures. The Force Transformation Office conducted one of these studies.[i] Its design focused on how to complicate both an adversary's combat problems and a potential adversary's own force planning.

OFT pulled together three variations of a fleet design that differed significantly from the fleet the Navy currently envisions. The major differences were, first, a smaller number of larger ships capable of providing high volume firepower, aviation, troop spaces, module support at sea, and logistical transport as needed. Second, the OFT alternative had a larger number of smaller ships, designed to accept different weapons, sensor, and transport modules. Third, while this alternative used the same number of manned aircraft the Navy currently programs for the future, it included a larger number of unmanned aerial vehicles. The OFT alternative substituted Air Independent Propulsion submarines for the Virginia class SSNs on a cost basis of roughly four to one and had larger numbers of unmanned undersea vehicles. The study kept the alternative at an equal cost to the Navy's programmed fleet in terms of procurement and 30 years operating and support costs.

The individual ships in this alternative were generally less potent and less technically complicated than those of the programmed fleet; smaller ships simply can't carry as much. But as Table 1 below indicates, the increase in numbers was impressive. (The "formation type" in the first column adopts the Navy organization. It organizes its combat forces around Carrier Strike Groups , or "CSGs"; Expeditionary Strike Groups, or "ESGs"; and Surface Strike Groups, or "SSGs". Attack submarines are part of these formations, but the table does not include attack submarines that are not normally operating as part of these formations. Nor does it include strategic ballistic missile submarines, or support ships that are not organically part of the formations listed – such as the support ships in the Combat Logistics Force.) The alternative portrayed is one of three variations developed in the OFT analysis. All three cost roughly the same, both compared to the programmed Navy fleet and to each other.

Table _1_

Programmed and Alternative Fleet Sizes (Combatants and Unmanned Vehicles)

Formation Type	Programmed	Force Transformation Office Alternative
Carrier Strike Group	96	396
Expeditionary Strike Group	120	324
Surface Strike Group	27	54
Total Combatants	243	774
Unmanned Vehicles	0	1,368

How effective would such a force be, compared to the force that will emerge if the United States sticks to the path the Navy says it wants to pursue?

The answer is pretty good. At least from an analytic standpoint, the alternative fleet provides some impressive advantages, particularly in the context of efforts to help project power ashore and support US ground forces.[ii] This is a very demanding challenge because it requires operating in the complex littorals. This is an arena in which an opponent can fight from land, sea, and air, where it's much harder to locate, identify, track, and attack his forces because they can "hide" within non-combatant populations, structures, and vehicles, and where the physical environment itself complicates the return from acoustic, radar, electronic, and visual sensing.[iii]

It is also an arena where analysis indicates an alternative fleet provides superior capabilities because its numbers, agility, modularity, profusion of multiple sensing assets, and networking give it marked offensive and defensive edges. Similarly, the alternative fleet offers important advantages at the other end of the sea environment – the open sea – where numbers, modularity, speed, and agility provide relative gains in controlling the operational domain.

Obviously, OFT had the luxury of thinking about the kind of Navy the United States should build from an analytic perspective, free from the constraints of political and bureaucratic influences and considerations. But the analysis began with a straight-forward question: what was technically and financially feasible if you based a fleet design on the assumptions of imposing complexity on potential opponents and the value of moving toward a fleet that reflected the more numerous, faster, networked hypotheses sketched out earlier. So, some might argue that OFT's projection is not as realistic as it might be because it does not recognize the politics of shipbuilding, or the influence of tradition. The rejoinder is this: it is at least as unrealistic to believe that the Navy can shrink itself to greatness as its current plans indicate it is about to attempt.

New Force Structure Design Metrics

The factors generating advantages for the alternative fleet apply generally. That is, the technological changes that enable modularity and networking for the Navy apply to US ground and air forces as well. Just as precision guidance for munitions allows smaller naval platforms to carry the destructive potential once associated only with large ships, thereby decoupling power and survivability from size, so do these attributes apply to all of the military services. The capacity of information to substitute for mass applies to the structures of each military service and the fact that sensor proximity and persistence will drive the utility of weapons reach applies to them all as well. Because of advances in guidance systems, distance no longer affects precision as it once did, and the key to effective fires is now almost entirely a function of knowing where the enemy is located--and deciding to attack quickly enough and with weapons that deliver their destructive effects fast enough.

That last point is worth noting because it represents an important qualitative change. There's a coupling between moving information and moving things, and we're witnessing a new and growing gap between our ability to move digital information bytes and our ability to move molecules. In early 2005, General Richard Cody, then in charge of all US ground forces in Iraq, told the Office of Force Transformation, "the situation we're in right now is that the information and events go a lot faster than our legs can." He was pointing to one of the great tipping points of our times; we're at the point now where our information capabilities are starting to exceed our physical capabilities. That's a big change. Our physical capabilities used to exceed our information capabilities -- we could *do* so many things with our military forces, but we just couldn't get the information in time that would tell us how and when to apply the force – to do those required things. Now, we're moving to a general condition where we know what to do, but can't bring the power to bear fast enough to take advantage of our knowledge. That's one of the tectonic shifts that underline the structural interest in moving toward the small, the fast, the many and the networked. The US military needs to move in that direction in order to get operating units into positions where they can generate weapons effects faster. And we ought to get serious about speed-of-light weaponry – that is, fielding directed and re-directed energy devices.[iv] Speed of light will help to start redressing the mismatch between information and atoms.

All of the military components recognize the factors outlined here. They are addressing them, however cautiously, in their operations and in their structural designs. But there are two other design factors they have not yet fully embraced. One is mass customization. The other is replacing integrated systems with networked components.

Mass Customization.

Defense procurement has traditionally sought to build duplicates of the same thing, relying on long production runs, and evolutionary improvements. The pattern provided steady, marginally larger profits for the producers and standardization, steady training and learning curves, and predictability for military consumers. But in the information age, where military power increasingly flows from adapting rapidly evolving IT, mass customization eclipses the value of mass production. Mass customization refers to producing goods and services that fit a wide range of different requirements in order to tailor capabilities for rapidly changing conditions and experimentation. The commercial world offers examples of this approach. The automobile industry is not one of them. For decades, automobile manufacturers have provided different versions of a basic automobile model, and have integrated the notion of customization into their sales pitches. For the most part, the extent that customers can actually go beyond superficial modifications (its debatable whether pin striping is meaningful customization) has been limited. But the concept of mass customization is expanding in the commercial world, and in some sectors, the ability of the consumer to modify basic models to fit their particular needs is quite impressive. Dell, a leading computer producer, allows customers to "design" a significant range of capabilities into the basic model they buy – hard drive memory, CD writer, etc. – at about the cost of the basic model.

The alternative Navy fleet architecture sketched above integrates mass customization by using a ship hull with common interfaces that allow the substitution of major systems – weapons suites, sensors, or unmanned vehicles. The best example of the approach so far is the Littoral Combat Ship (LCS) the Navy is now starting to build. The range of capabilities it will provide will be impressive because each hull will have configuration, mission, and battle network modularity. That is, the configuration of a given LCS will be a function of the weapons, electronics, and the ship's technical equipment modules that the operators "plug" into the hull. The hull, in essence, will function like a common chassis. Its mission capabilities will reflect the containerized weapons and other equipment packages they add, and its battle network modularity will flow from both the sensor and communications modules it carries, and, from the multiple module ships contributing to the operationally distributed network within which they will operate.

Mass customization is not limited to naval forces because what makes it possible – advances in technology, particularly in programmable, computer-based machines, modules that conform to standard interfaces, and networked systems – apply not only to the various platforms on which Army and Air Force components depend, but also to the organizations they employ. The Army is beginning to implement this notion in its Future Combat System (FCS) and the Air Force would argue – without too much exaggeration – that its interest in multi-role fighters (like the F-16) pioneered mass customization for the military services.

None of the military services talk much about the strategic competitive advantage of wider and deeper use of mass customization, however. That is, they do not often recognize the accelerated experimentation inherent in the concept, nor how it can help open up a wider range of options and flexibility in the design of future forces. Mass customization coupled with modular design enables the military to rapidly configure new and different joint units with many capabilities. To the extent it suffuses the force structures, it multiplies the base with which to continually experiment in the search for ever more effective means of merging advanced technology with the military structures, organizations, and operational schemes that can take full advantage of the technology.

The combination of mass customization and modular design enables the military to reduce the cycle time for introducing new capabilities. This is easiest to demonstrate for platforms – ships, aircraft, and large ground combat vehicles – because the cycle times for primary structural materials or propulsion systems is generally so much longer than the cycle times for communications and other information technology. Figure 1, for example, illustrates the differences for ships, but the difference in cycle times for platforms like tanks or aircraft and the communications and other information technology they carry is similar. To the extent that these different cycle times are integrated in rigidly standardized platforms, the evolution to new capabilities tends inevitably toward the longer cycle times. The integration makes it difficult to add new generations of communications and information technology without modifying the platforms, and a commitment to standardization ties the rate of change to that required to modify the whole fleet of platforms. A design commitment to modularization, however, makes it much easier and faster to swap out new cycles of equipment. And that allows more rapid introduction of new capabilities. Shifting toward mass customization also frees the rate of experimentation and development of new operational capabilities from the drag of standardization.

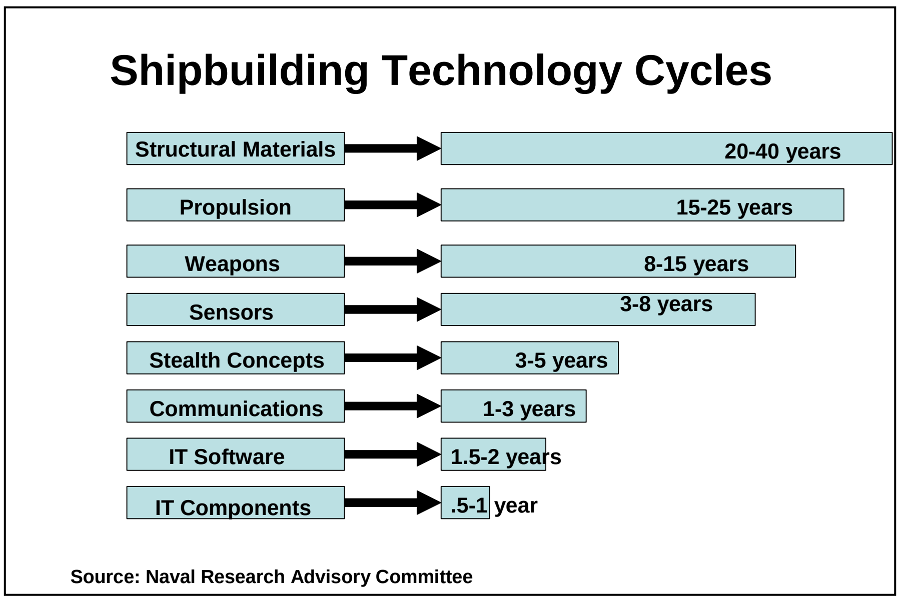

Figure 1

In short, modular design and mass customization multiply the future force options open to the United States. And that degrades the ability of potential opponents to precisely forecast the kinds of future capabilities the US military will have, thereby easing their planning burdens. This is the force planning equivalent of the operational desirability of confronting an opponent with overwhelming complexity. It is a cost-imposing strategy on potential opponents.

Networked Components Vice Integrated Systems

Generating more design options and therefore imposing new difficulties on a potential opponent's ability to forecast what the US military will look like is also a product of moving toward networked components. The tangible aspect of this shift is modularity: replacing the notion that weapons, communications, sensors and other equipment must be an integrated, organic part of either platforms (ships, aircraft, ground vehicles) or unit structures, with the concept that the tangible pieces of equipment that provide fire, sensing, communications are “plugged” into the platforms or units.

The intangible aspect is more complicated. It is a shift away from seeing a given military force as the sum of the capabilities provided by each unit and instead envisioning it as the product of the capabilities of all the units; a force that draws its power from the synergy among units. A highly integrated system ship, like the Arleigh Burke-class destroyers or what emerges from the DDX program, combines firepower, sensor, command, and communications together so that it can operate autonomously. Networks, and ships designed for them, however, allow systems to be separated and placed on smaller, specialized platforms without losing the ability to create precise, coordinated effects. This allows the components of the networks – platforms or units – to be smaller, faster, and more maneuverable. The force the network creates can disperse, cover wider areas, and as such, provide a broader perspective to all its components. Operationally, it is more flexible. And therefore better able to operate within an opponent’s decision and action cycles. More complex--and therefore more difficult for an enemy to counter—and less vulnerable, and therefore more powerful.

The strategic analogue to the shift toward networked force component operations is similar. To the extent the United States shifts its force structure design away from single integrated systems toward networked components it imposes more complexity on an opponent’s effort to design a force structure to counter US military capabilities. This impacts any potential opponent, from a conventional military to a terrorist organization. To the extent that opponent seeks to hedge its bets by broadening its traditional military capabilities to cover the greater complexity, we impose additional costs on their attempts.

Force Planning Decision Rules

While the dominant force planning rule may now be to seek to impose greater complexity on potential opponents, actual force planning always boils down to choosing among different ways to achieve these strategic aims. So, here are some important decision rules.

- The advantage goes to systems, weapons, and operational concepts that increase US overall capacity to gather, communicate, and use information effectively. It's an information edge that makes the smaller, faster always better than the larger and slower in military affairs. Over the last decade it has become increasingly obvious that the key to military success is to obtain an information advantage and that requires a superior sensor position. That is, we have to be able to gather more information, draw more relevant knowledge out of that information, and get that information to the force components that can use it, faster and better than an adversary can. Doing this is in part a function of the breadth and depth of our sensors – ideally, they should cover the world and draw information from across the acoustic and electromagnetic spectra. But sensor position refers not only to what information they can gather, but what they can do with it. So, again ideally, sensors that we have everywhere drawing information from across the acoustic and electromagnetic spectra ought to all be part of an information network. Not just technical devices are required. Men and women, some of the best sensors, are included.

  Push this into a standard for deciding among competing claims for resources and you get the discriminator of whether the contender is "on the net." If not, then it is not contributing, not benefiting, and not part of the information age. Defense advocates for programs that fail to contribute to joint force interdependence ought to be simply nominating their programs for cancellation.

- The second rule is that the advantage goes to the program or proposal that increases the breadth of US military capabilities. This is another of those radically different presumptions of the information age that replaces what was so central in the late industrial age. Then, the Defense Department focused on trying to answer, "how much was enough" to cope with a particular, relatively well understood threat. Now, the issue is do we have the breadth of capabilities needed to manage risks in the information age. In choosing among demands for resources, the nod ought to go to the contender that extends the breadth of our capabilities rather than the one that adds to an existing capability.

The controversial side of this rule is that it runs up against the traditional military penchant for redundancy. Yes, you can interpret the rule of extending the breadth of our capabilities as justifying having a lot of the same capability, in the sense that the more you have, the more you can do and the more you can reduce the risk of not having enough. But breadth here means diversity rather than redundancy, in part because of the increased synergy it produces and the increased complexity it imposes on an opponent. The controversy inherent in this rule flows from its refutation of, for example, the notion that the United States needs four air forces – one painted Army, another Navy, a third Marine Corps, and, the fourth painted Air Force. Or that the Army and Marine Corps ought to converge in terms of equipment. Diversity of capabilities and forces is what imposes complexity, and therefore what has an inherent edge in expanding the breadth of US military capabilities.

- The final rule is that the advantage goes to the claimant on resources that is performing or will perform at an increasing rate of return on the investment. The Army's Crusader artillery system is an example of one that didn't meet the test. It was clearly going to be a better cannon in the context for which it was designed. But the altered strategic environment devalued that consideration. In the information age there are better ways of providing what the Crusader promised: low cost, high volume of fire and short response times. In Afghanistan, aircraft, precision munitions, and long-range dispersed joint capabilities empowered by high-speed network centric warfare concepts were more effective than the Crusader could have been. A mix of small, fast, diverse networked systems that extend the overall breadth of our military capabilities will perform at increasing rates of return on an investment. The Crusader would have performed at decreasing rates.

How do you increase the likelihood that what you decide to produce will have an increasing rate of return on your investment? You have to break the iron notions that once something becomes a program of record, you should not seek alternatives to it. You have to take spiral development seriously. You have to be willing to see any program as a potential technology exploration and drop it when it doesn't look promising or incorporate the technology it demonstrates elsewhere instead of containing it to a single program.

If you use these propositions to distinguish the things the Defense Department should invest in from those that it should not, you get a set of more specific guidelines that provide transformation decision logic. The guidelines begin by asking if a candidate – it can be a weapon, support system, or something less tangible, like a force structure or operational concept – is transformational. That is, does it enable a new concept of operation and represent a difference in kind, not degree? If so, is it robust in the face of a wide range of threats? Does it broaden the capabilities of the force? And does investing in it promise an increasing rate of return on that investment? "Yes" to each of these questions signals a transformational winner. "No" indicates a loser.

NOTE: *Transformation Trends is provided as a means to highlight new and emerging issues in defense and commercial realms to key decision-makers and in no way constitutes endorsement or official recognition of any idea, concept or program.*

[i] Office of the Secretary of Defense, *Alternative Fleet Architecture Design: Report for the Congressional Defense Committees* (Washington, DC: 2005); Report requested by the United States House of Representatives in House Report 1588, Section 216 of the National Defense Authorization Act for Fiscal Year 2004.

[ii] See, for example, Institute of Defense Analyses, *Comparison of Potential Future Fleet Architectures* (Arlington, VA; IDA Paper P-3980, January 2005).

[iii] Among the phenomena that complicate acoustic, radar, and visual sensing in littoral regions are the relatively rapid changes in water salinity and temperature (that make the analysis of acoustic returns more difficult), the shadowing effects of nearby land topography and surf torpidity (that make the analysis of radar returns more difficult), and the density of non-combatant ships, boats, structures, and populations (that make discrimination and differentiation of military targets much more difficult).

[iv] Directed energy weapons include acoustic and electromagnetic generators, but only the latter are capable of delivering energy at the speed of light. While weapons research has investigated a number of electromagnetic phenomena -- including X-rays, high frequency radio, and microwaves – devices which use visible light in the form of a laser (**L**ight **A**mplification by **S**timulated **E**mission of **R**adiation) is the closest to weaponization for lethal and non-lethal applications across great distances. The Department of Defense currently funds three kinds of laser technology for High Energy Laser Weapons (HEL, in the military acronym): Chemical, Solid-State and Free Electron. Each of these technologies can produce high-energy light at a particular wavelength. But a laser weapon system also requires delivering the laser power in such a way that the laser beam can deliver a lethal or disruptive fluence on the target (fluence is the energy per unit area deposited by the laser on the target). During propagation through the atmosphere molecular constituents and air density cause scatter and absorption that attenuate and spread the beam. The effects are considerably worse near the surface of the earth than at high altitudes.

This, and the fact that laser devices generate beams that move in straight lines has focused interest in airborne or space-based platforms to extend the range of their operational use. Over the last several years, however, the Defense Department has developed effective techniques for compensating for the effects of the atmosphere, and relatively low weight mirror-like devices are able to redirect the beams to other vector paths. A "redirected energy weapon", then, refers to a two step mechanism involving a generator and a device that redirects the beam to the target.